TWO NEW SUBSPECIES OF *CROTAPHYTUS* (SAURIA: IGUANIDAE)

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Abstract.— Analysis of the *Crotaphytus collaris* complex reveals at least eight subspecies in two distinct groupings. The *collaris*-complex containing *C. c. auriceps*, *C. c. baileyi*, *C. c. fuscus*, and *C. c. collaris* lies essentially to the east of the Colorado River. The greatest portion of the western-complex containing *C. c. bicinctores*, *C. i. vestigium*, *C. c. dickersonae* and *C. i. insularis* lies to the west of the Colorado River except through western Arizona and northern Mexico. Two previously undescribed subspecies, *C. c. bicinctores* and *C. i. vestigium*, are described and named.

This paper presents a brief portion of an extensive study of the western collared lizards from the Great Basin and the Baja California Peninsula. The complete report will soon appear in the Biological Series of the Brigham Young University Science Bulletin.

The range of the western collared lizard, *Crotaphytus collaris baileyi*, includes a vast area of the western United States and Mexico. One of us (Tanner, in Fitch and Tanner, 1951; Ingram and Tanner, 1971) has suspected for a number of years that the lizards occurring in this vast area represent a heterogenous population. Stejneger (1890) described *Crotaphytus baileyi* as a species; however, as data became available it was recognized to be a western subspecies of *Crotaphytus collaris* Say (1823), the form found east of the Continental Divide. Two insular forms, *Crotaphytus dickersonae* Schmidt (1922) from Tiburon Island, and *Crotaphytus insularis* Van Denburgh and Slevin (1921) from Angel de la Guardia Island, Mexico, although given species rank, have long been recognized as closely related to *C. c. baileyi*. Allen (1933) referred to the collared lizards from Tiburon Island as *C. c. dickersonae*. Burt (1928) considered all collared lizards to be closely related.

Fitch and Tanner (1951) established *C. c. auriceps* from the upper Colorado River Basin. Ingram and Tanner (1971) reaffirmed *C. c. auriceps* as a subspecies and, upon redefinition of the characteristics of *C. c. baileyi*, established *C. c. fuscus* as a subspecies found in the Chihuahuan Desert south of the range of *baileyi*. The type locality for that subspecies being 6.5 miles N and 1.5 miles W of Chihuahua City, Chihuahua, Mexico. The techniques described by Ingram and Tanner (1971) were used to compare four subspecies of the western-complex with four subspecies of the *collaris*-complex. This technique permitted both an intercomplex and an intracomplex comparison.

Relationships

To determine relationships, Ward's Minimum Variance Cluster Analysis (Wishart, 1968) was used to group lizards in clusters of highest morphological similarity. Lizards were chosen to represent

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the range of the geographic locations available, and 150 lizards were used as input. A random sample was taken from each area and included: Great Basin (N=20); Baja California Peninsula (N=20); Angel de la Guardia Island (N=17); Tiburon Island (N=13); Upper Colorado River Basin (N=20); Central Arizona (N=20); Chihuahuan Desert (N=20); and the Great Plains (N=20). A contingency table was prepared comparing these groupings with the eight groupings formed by the cluster analysis (Table 1). The null hypothesis (the two classifications, one by closest morphological resemblance and the other by geographical location, are completely independent of each other) was tested by a chi-square of 49 degrees of freedom. The test is significant at the 0.001 level.

$$X^2(1-\alpha,49) = \sum_{i=1}^{m}\sum_{j=1}^{n}(O_{ij}-E_{ij})^2/E_{ij}$$

$$X^2(1-\alpha,49) = 485.7$$

$$X^2(0.999,49) = 85.4$$

Therefore $X^2(1-\alpha,49) \geq X^2(0.999,49)$ and the null hypothesis is rejected, and the morphological relationships of the lizards examined form essentially the same groups as those proposed in Table 1.[2]

TABLE 1. A contingency table testing the independence of Ward's clustering method and the proposed groups as follows: A = Great Basin, B = Baja Calif., C = Angel Is., D = Tiburon Is., E = Upper Colo., F = Central Ariz., G = Chih. Desert, H = Great Plains.

	PROPOSED GROUPS							
	Western-Complex				*Collaris*-Complex			
Clusters	A	B	C	D	E*	F	G	H
1	4	6	0	6	0	0	0	0
2	0	12	0	7	0	0	0	0
3	16	0	0	0	0	0	0	0
4	0	2	17	0	0	0	0	0
5	0	0	0	0	9	9	2	4
6	0	0	0	0	9	5	4	4
7	0	0	0	0	2	2	12	0
8	0	0	0	0	1	3	3	11

*The data for the Upper Colorado Rive rBasin and central Arizona does not contain the key characters which distinguish *C. c. auriceps* and *C. c. Baileyi*.

It is noted that none of the western-complex clustered with those of the *collaris*-complex; however *C. dickersonae* which had been given species rank was not as distinctly clustered. This lends additional support to the suggestion (Burt, 1928; Allen, 1933) for revision of this group. We propose that it is a subspecies of *C. collaris* and should be called *Crotaphytus collaris dickersonae*. We have collected on Tiburon Island and also on the Sonoran Coast opposite the island and have found specimens from these two areas to be indis-

[2]We have done little with the populations occurring on the Great Plains. Our data does, however, suggest that a careful study may reveal additional collared lizard populations worthy of subspecific recognition. We have deferred the study of these populations to R. Montanucci.

tinguishable. Schmidt (1922:639) stated this possibility when he said of *C. dickersonae* "it is possible that this species will be found to extend on the Mexican mainland and that it will ultimately be referred to a subspecific rank under *C. collaris*. . . ."

The other insular form, *C. insularis*, remains a very distinct population closely related to the collared lizards occurring on the Baja California Peninsula. These two populations are very similar in pattern and external morphology. The Angel Island form has the second collar much reduced or absent, and with 39-45 subdigital lamellae on the fourth toe. Individuals on the Baja California Peninsula extend their range north to Palm Springs, California, and form a narrow zone of sympatry with the Great Basin subspecies at the most northern part of their range. Because of these morphological and biological relationships, the population from Angel Island is designated *Crotaphytus insularis insularis* and those from Baja California as *Crotaphytus insularis vestigium*.

There are several characters which distinguish the western-complex from the *collaris*-complex. In the western-complex, the second collar does not extend onto the arm, there is a prominent black groin patch in the males, spots are absent in the dorsum of the first collar, and there are more scales between the interparietal and the anterior edge of the first collar. Diagnostic characters within the western-complex are discussed in the diagnoses of the new subspecies.

Crotaphytus collaris bicinctores, subsp. nov.

HOLOTYPE.— Adult male Brigham Young University no. 23883, collected at Mercury Pass, Nevada Test Site, Nye Co., Nevada, 14 June 1966, by W. W. Tanner.

PARATYPES.— BYU nos. 22191, 23629-30, 30587 (all topotypes) from the Nevada Test Site, Nye Co., Nevada; BYU 12715, Western Beaver Co., Utah; BYU 12696, 12701, N Wash, W side Colorado River, Garfield Co., Utah; BYU 18921, Crossing of the Fathers, Kane Co., Utah; BYU 21000-02, Black Rock Mountain, Millard Co., Utah; BYU 32097, 52 miles N Yuma, route 95, Yuma Co., Arizona; CAS 37055, Caliente, Lincoln Co., Nevada; CAS 22705, Dayton, Lyon Co., Nevada; LACM 63187, Big Rock Creek at Dorr Creek, Los Angeles Co., Calif.; LACM 63182, Sweetwater Spring, Ord Mts., San Bernardino Co., Calif.; SDSNH, 1444, Hot Springs, Owyhee Co., Idaho; CSCLB 2736, 4 miles N Yermo, San Bernardino Co., Calif.; CSCLB 2735, Mule Canyon, Calico Mts., San Bernardino Co., Calif.

DESCRIPTION OF TYPE.— Snout-vent length 95 mm, tail length 177 mm, width of head at angle of jaw 20.5 mm, hindleg length from midline to tip of fourth toe 88 mm, femoral pores 17-19, supralabials 16-15, infralabials 14-15, fused interorbitals 0, frontoparietals 3, loreal-lorilabial series 9, postmentals not in contact with infralabials, gular scale rows from angle to angle of jaw 61, scales from rostral to interparietal 16, scales from interparietal to anterior edge of first collar 32, scales from anterior edge of first collar to posterior edge of second collar 32, total dorsals 161, total ventrals 195, scales

within dorsal separation of first collar 1, scales within dorsal separation of second collar 0, number of spots within dorsal separation of first collar 0, subdigital lamellae of second toe of right hind foot 19, subdigital lamellae of fourth toe 39, subdigital lamellae of fifth toe 18 (Fig. 1 and 2).

Type a preserved specimen in which coloration closely resembles living organisms. Reticulation of the chin and parietal area resembles freckles with this pattern extending to posterior dorsum of

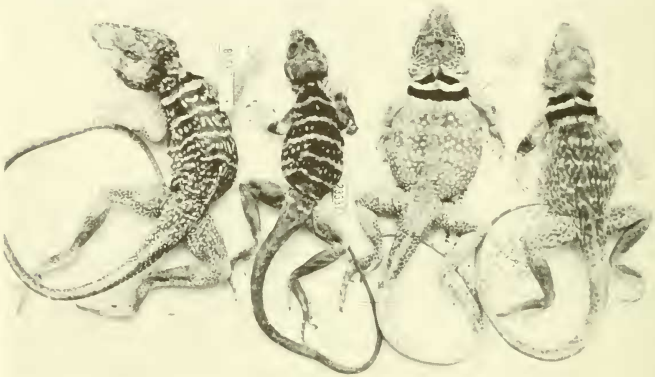

Fig. 1. A dorsal view from left to right of *Crotaphytus insularis vestigium*, male BYU 23338, female BYU 23337 and *Crotaphytus collaris bicinctores*, male BYU 23883, female BYU 23629.

Fig. 2. A ventral view from left to right of *Crotaphytus collaris bicinctores*, female BYU 23629, male BYU 23883 and *Crotaphytus insularis vestigium*, female BYU 23337, male BYU 23338.

head. Body dorsum light brown, never green, venter cream with black patches in groin and axillary regions. First collar nearly complete dorsally and merging ventrally with black of gular area. Second collar complete dorsally, not extending onto upper arm. Dorsal body pattern rather uniformly dotted with light spots and with two diffuse cross bands. Forelegs, hindlegs, and tail brown, reticulated with white. Dorsum of tail ridged and tail compressed laterally.

DIAGNOSIS.— The Great Basin population differs from *C. c. baileyi* of the *collaris*-complex in many of the 32 characters measured and particularly in the following which are listed with their coefficient of difference (Mayr, 1969): dorsal separation of the first collar (1.63); number of spots in dorsum of first collar (1.45); number of enlarged median internasals (1.39); and brown dorsal ground color (1.33). Other characters include second collar not extending onto the arm, greater number of scales from interparietal eye to anterior edge of first collar, and more extensive black coloration of the ventral groin.

The Great Basin form can be distinguished from the Baja California and Angel de la Guardia Island populations by a more complete first (1.4) and second (1.84) collar dorsally. It is distinguished from *C. c. dickersonae* by its dorsal brown coloration, back pattern, and several other characters which considered alone are not significant but that give good population separation when computed together in the clustering program (Table 1).

RANGE.— Extends throughout the Great Basin region. Apparently does not occur east of the Colorado River in Utah, but does cross the Green River and may intergrade with *C. c. auriceps* in this region. The Colorado River continues as a barrier south to Oatman, Mohave Co., Arizona, where we have captured the Great Basin subspecies. Twenty miles to the east in Kingman, Arizona, *C. c. baileyi* is found. This is an area of possible intergradation that needs further investigation. The Great Basin form continues on the east side of the Colorado River down to Yuma Co., Arizona. The area of intergradation with *C. c. fuscus* and *C. c. dickersonae* is incompletely known. In southern California, it extends to the San Gorgonio Wild Area and the Whitewater River Canyon northwest of Palm Springs, Riverside Co., and apparently crosses the the narrow sandy valley of the San Gorgonio Pass to reach the eastern foothills of the San Jacinto Mountains where *C. i. vestigium* is found (Fig. 3).

Crotaphytus insularis vestigium, subsp. nov.

HOLOTYPE.— Adult male, Brigham Young University no. 23338, collected in Guadelupe Canyon, Juarez Mountains, Baja California, 15 July 1965, by James W. Heinrichs.

PARATYPES.— BYU nos. 23337, 23339, 22298-99 (all topotypes) Guadalupe Canyon, Juarez Mts., Baja Calif.; BYU 33321, Mt. Springs, Imperial Co., Calif.; BYU 2422, 2432, 2435, Chino Canyon, Palm Springs, Riverside Co., Calif.; BYU 2429-30, Snow Canyon, Palm Springs, Riverside Co., Calif.; SDSNH 1687, 11951, Palm Can-

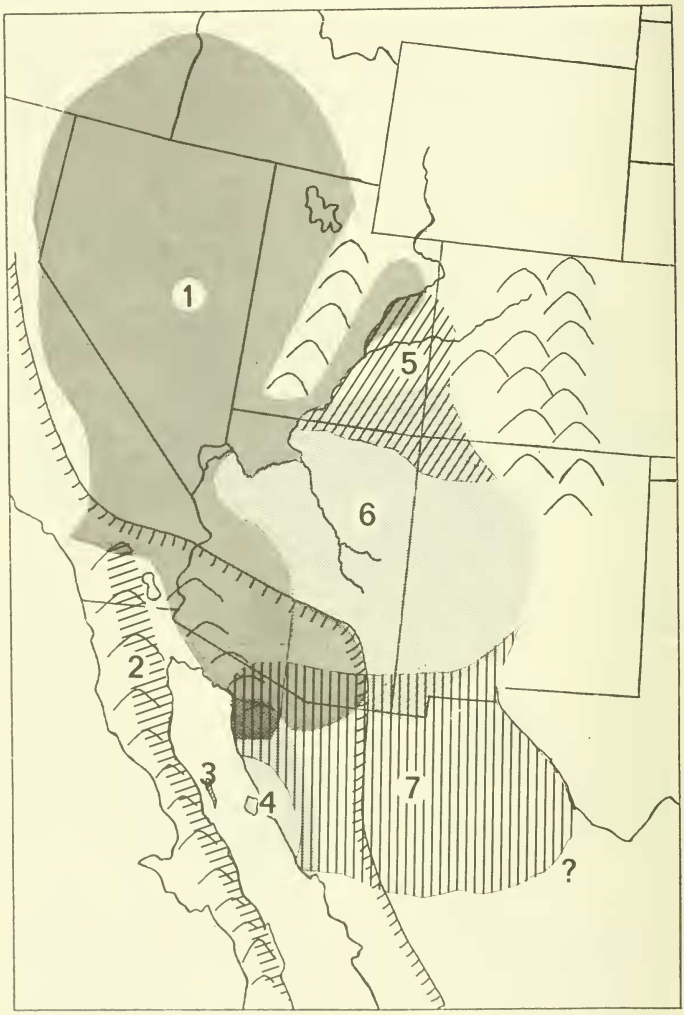

Fig. 3. Geographical distribution of the western subspecies of *Crotaphytus collaris*: 1, *C. c. bicinctores*; 2, *C. i. vestigium*; 3, *C. i. insularis*; 4, *C. c. dickersonae*; 5, *C. c. auriceps*; 6, *C. c. baileyi*; and 7, *C. c. fuscus*.

yon, San Diego Co., Calif.; SDSNH 11088, Pinon Mt., San Diego Co., Calif.; SDSNH 22327, Sentenac Canyon, San Diego Co., Calif.; LACM 16997-98, Los Angeles Bay, Baja Calif.; CAS-SU 17048, Sierra San Pedro Martir, Baja Calif.; CAS-SU 18822, 9 miles W San Ignacio, Baja Calif.; CSCLB LWR670619-1 and 670619-2, 11 miles W Santa Rosalia; CUM 45855-6 and 45858, 14.8 miles S Puerto Citos; CUM 45857, Okies Landing; and CUM 45859-61, S end San Luis Gonzalga, N Puerta Final, Baja California.

Description of Type.— Snout-vent length 111 mm, tail length 252 mm, width of head at angle of jaw 23.8 mm, hindleg length from midline to tip of fourth toe 102 mm, femoral pores 18-21, supralabials 15-16, infralabials 16-15, fused interorbitals 0, frontoparietals 3, loreal-lorilabial series 10, postmentals in contact with infralabials, gular scale rows from angle to angle of jaw 67, scales from rostral to interparietal 16, scales from interparietal to anterior edge of first collar 40, second collar absent, total dorsals 180, total ventrals 205, scales within dorsal separation of first collar 17, number of spots within dorsal separation of first collar 0, subdigital lamellae of second toe of right hind foot 20, subdigital lamellae of fourth toe 40, subdigital lamellae of fifth toe 23.

The type is described from a museum specimen in which the coloration compares favorably with live specimens seen from the foothills NW of Palm Springs. Reticulation of head present as in *C. c. bicinctores* but with larger freckles; body dorsum brown with large oblong spots and three nearly complete light colored cross bars. First collar widely separated dorsally and merging ventrally with black of gular area. Second collar absent. Forelegs light, spotted with brown hindlegs and tail brown, spotted with white. Dorsum of tail ridged and compressed laterally.

Diagnosis.— Similar to *C. c. bicinctores* in many respects but with greater dorsal separation of the first and second collars, with distinct dorsal light cross bars, and a smaller second collar length/snout-vent length index. The Baja subspecies can be distinguished from *C. i. insularis* Van Denburgh and Slevin (1922) to which it is most similar, by fewer toe lamellae on the second and fourth toe, larger second collar/s-v index, and a smaller dorsal separation of both the first and second collars.

Range.— East side of the mountains from central Baja California, north to Palm Springs, Riverside Co., California. It does not occur on the western Pacific slopes in California, and apparently does not intergrade with *C. c. bicinctores*, although these papulations are in close proximity in the Palm Springs area.

Specimens Examined

A total of 150 specimens from eight populations were used to make comparisons. Twenty from each population except *C. i. insularis* and *C. c. dickersonae*, where only 17 and 13 were available respectively for the computer analysis.

C. c. bicinctores

California: Kern Co., BYU 31948; Riverside Co., BYU 32099.

Idaho: Butte Co., BYU 30772; Owyhee Co., BYU 2834.

Nevada: Clark Co., BYU 461; Nye Co., BYU 18815, 22194, 23882, 30088.

Utah: Emery Co., BYU 20090; Millard Co., BYU 8755, 8883, 21000, 21703; Tooele Co., BYU 14818, 14820-21; Utah Co., BYU 1455, 13041; Washington Co., BYU 12875.

C. c. dickersonae

Tiburon Island: CAS 14005-06, 14008-12, 53263-64; SDSNH 46003-06.

C. i. insularis

Angel de la Guardia Island: CAS 21948, 50874-76, 50878-79, 86754-55, 86783-84; CAS-SU 22712; LACM 4001-02, 9854; SDSNH 46001.

C. i. vestigium

Baja California: Canyon Guadalupe, Juarez Mtns., BYU 23337-39, and BYU 22298-99; North of Canipole, SDSNH 30109-111; Coyete, SDSNH 52999; Baja Sur, SDSNH 30107; Los Angeles Bay, SDSNH 19789-90, 41612, 52950; Las Palmitos, SDSNH 17052; North Gonzaga Bay, SDSNH 19791-92; Sierra San Pedro, CAS-SU 17048; Santa Rosalia, CSCLB LWR670619-1 and 670619-2.

C. c. baileyi

Arizona: Apache Co., BYU 497; LACM 16895; UIMNH 7524; USNM 29184. Coconino Co., BYU 506, 11388; UIMNH 6543, 35945; USNM 15821. Graham Co., UIMNH 24507; USNM 5153, 51737. Mohave Co., BYU 32116; UIMNH 74778, 74781. Navajo Co., BYU 13574. Pima Co., LACM 3983; SDSNH 15214. Yavapai Co., BYU 33322; UIMNH 5900.

C. c. auriceps

Colorado: Mesa Co., BYU 11342. San Miguel Co., CUM 1333, 4448, 4450, 4451, 4453.

Utah: Grand Co., BYU 1625, 10338, 12854. San Juan Co., BYU 1461, 1464, 12619, 13006-08, 16484, 21706, 32088; UU 1461, 2427.

C. c. fuscus

Mexico: Chihuahua, BYU 13383-86, 13410, 14211; KU 3378, 33789; UC 70704; USNM 14242.

New Mexico: Dona Ana Co., LACM 3971; USNM 22268. Luna Co., BYU 31940; USNM 44955, 80072. Sierra Co., LACM 3981.

Texas: El Paso Co., USNM 59351, 59352; UTEP 52; UU 493.

C. c. collaris

COLORADO: Los Animas Co., CUM 1292, 2939.

KANSAS: Montgomery Co., BYU 22167. Wilson Co., KU 41, 45, 46, 48, 54.

NEW MEXICO: Chaves Co., LACM 3974, 3975. Lincoln Co., LACM 16990. Quay Co., USNM 44940.

OKLAHOMA: Carter Co., BYU 500, 1574.

TEXAS: Garza Co., CUM 32277. Randall Co., CUM 13554-56. Roberts Co., USNM 32866. Stephens Co., BYU 13177.

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